"On the Illiterate Child, Named Jacques Arnodi, Gifted with the Faculty of Performing Very Complicated Calculations"

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Dr. Paul Broca, the Father of Craniology

Messieurs, you remember that during our last meeting our colleague Monsieur d'Abbadie talked to us about the singular faculty that aids certain individuals in being able to perform in their head very complicated calculations without assistance from ordinary arithmetic.

Two days later, Monsieur X … who is today present at our meeting, came to me, introducing me to an eleven-year-old boy who possesses this faculty to a remarkable degree.

As you see, this child, named Jacques Arnodi, is also with us today. Although he was born in Coni (Piedmont), Jacques has mainly lived in the south of France. He accompanies his father, a street organ player, asking for coins. For the last few months he has been living with his older brother who is a waiter at a café in Marseille. The habitués of the café learned that this boy knows how to do calculations in his head. They amuse themselves by posing questions to him, making him do large multiplications or having him extract square roots and cube roots; and whenever he

astonishes them, they give him a reward. Monsieur X…, having assisted at one of these small exhibitions, made arrangements with the older brother, and has conducted the boy here to Paris.

This boy is skinny, rather puny, and very small for his age. His trunk and limbs are well formed and do not present any signs of rickets. His head is quite voluminous in regard to his height; furthermore, it is quite irregular in shape. A longitudinal depression on the median line of the forehead indicates that the metopic suture is persistent. The forehead is quite convex; the two frontal bumps are both most prominent, but the right is much more so than the left. The parietal bumps likewise are very pronounced, above all the left, so a certain degree of plagiocephaly exists. This conformation cannot be attributed to hydrocephaly and instead seems due to cerebral hypertrophy.

The boy is very intelligent; his look is lively, his physiognomy animated. He does not have any timidity. He does not know how to read or write. He has and sees numbers in his head, but he does not write them down.

Monsieur X…, when he brought the boy to me, told me that he never makes mistakes in his calculations, which he performs quickly, and that he especially excels in finding the square root of a number. However, without wishing to diminish at all your astonishment, I must say that the boy sometimes does make mistakes, as much with multiplication as with extracting square roots, and that the calculations that he performs in his head, howsoever extraordinary that they are, are completed much more slowly than the computations that we do with a pen.

I first asked the boy to multiply a number by itself that I had taken from a table showing powers of 2. It was 65,356, I believe.

The Boy: It was not 65,356, but 65,536.

Doctor Broca: You see, messieurs, what a good memory he has for numbers; it was twelve days ago that I posed the question to him, and he remembered it better than me, even though on the one hand I have frequently had the occasion, in calculating probabilities, to avail myself of the Powers of 2 table, and even though on the other hand this remarkable child, having never before calculated beyond the third power or the cube root of these numbers, was entirely ignorant of, as you will see, the number that I had given him being the sixteenth power of 2.

He then began his multiplication, of which the product of 65,536 X 65,536 was under my eyes, and as he has the habit at the end of each of his partial operations of muttering his successive results, I have been able to apprehend some numbers and have established that he does not begin, like we do, by multiplying the units furthest to the right, but rather by multiplying the most elevated units, that is to say, by the units furthest to the left. I have not been able to account for the nature of his multiplication processes.

During this time, I continued to chat with Monsieur X…; the boy, though wholly engaged in calculating, followed our conversation and even mixed in some words, but without otherwise interrupting himself. Seven minutes elapsed in this manner, and I must say that by comparison, having performed myself the calculation by pen, I was able to finish the problem in one minute.

Henri Mondeux (1826-1861), the famous French human calculator predecessor to Jacques Arnodi

Incidentally, among other instinctive calculators who I have not observed, the renowned Henri Mondeux possessed, it is said, the faculty of calculating in his head faster than one can do by following ordinary arithmetical processes. I do not deny it, but this is not the case with our subject.

Now, at the end of seven minutes the boy made a magisterial gesture and said to me, "Here." And he then enunciated an answer that contained ten numbers, which began with 4 billion (I've forgotten the rest). The first seven numbers were correct, but the hundreds and tens column numbers were wrong. I do not remember any more about the error that he committed.

The Boy: I said 4,294,967,356 instead of 4,294,967,296.

Doctor Broca: I then told him that the billions, millions and thousands were fine, but that the hundreds were wrong. He reflected an instant, less than a half-minute, and gave me this time the exact number, telling me that I had been right.

Monsieur X…, surprised at the error of his pupil, then requested me to make the boy perform the operation in which he excelled—the extraction of a square root.

I therefore asked for the square root of the same number—65,536. The root in this instance is 256, the eighth power of 2. The extraction of the square root of a 5-digit number can be done in 45 seconds. The boy devoted a little more than two minutes in working the problem, eventually telling me with assurance "255."

I told him that his answer was incorrect. He started over, first once, then several times, and always answered "255."

The Boy: I was wrong. 256 is the right answer.

Doctor Broca: He began anew his calculating, doing so without wishing to desist, and from my discussions with him I am not confident that he knows one of the primary hints of arithmetic. I told him, "How do you see that in multiplying 255 by itself, which ends with a 5, one obtains 65,536, which ends with a 6?" I have thoroughly ruminated upon my objection, and the boy's consistently answering "255" is impossible for me to understand.

With regard to the process that he follows in order to extract square roots, I was able to easily discover it. It is a process of feeling one's way—groping, if you will—just like the one that we follow in order to find a word in the dictionary. If I search for the word *bon*, I open the book towards its beginning where I know from experience that the *B's* are located. If, for example, I land upon words that start with *ba*, I see that it is necessary to go on farther and therefore I advance. This time I land upon words beginning with *bu* and see that I must go back the other direction; but, if I go back too far and now behold words starting with *bi*, I once again reverse direction and go forward, drawing nearer and nearer to my word until I eventually find it.

The boy operates in the same manner. Although he has to an astonishing degree a memory for numbers, he does not yet know (perhaps he will later on) the square root of every number. However, he has inside his head landmarks which aid him in immediately recognizing that the square root of a number must lie between certain limits. He then successively tries, by squaring the various numbers contained within these limits (thanks to the faculty that he possesses of performing multiplications), to obtain the answer.

Thus, as soon as I had posed my question regarding the square root of 65,536, he immediately saw that the root must fall between 250 and 260, and in looking at his lips I saw that he was essaying first at 250. He found, though, that the square of 250 was too small; so, he tried out another number which I was unable to make out. Each time I noticed a slight movement of his head, indicating that he was trying out a new number. On his fourth attempt it appeared to me that he muttered "257."

The Boy: You are right.

Doctor Broca: Then, after a short pause, he told me his final answer—255—the number with which he was so infatuated.

Now, you ask, how was this process of approximation by feeling one's way able to induce an error? It is clear that in attempting 255 it will be discovered that this number is too small, and it is clear, consequently, that the boy had not tried out 255. His error consisted in his belief that he had worked all the other neighboring numbers, whereas in reality he had neglected to try out 256. Disappointed and intimidated by his previous bad luck, he lost his composure, and having jumped from 254, which was too small, to 257, which was too large, he believed that the only number that remained between these two was 255.

The Boy: That is what happened.

Doctor Broca: He had, messieurs, proceeded like the dog who, following a scent, arrives at a point where the path splits itself in three directions. He immediately engages himself by smelling

out the first of these three paths, exploring it carefully, but doesn't find anything, and returns to the junction, resuming his search. He next examines in the same way the second path without any more success, returns again to the junction and this time, without hesitating and without wasting his time on unnecessary inspection, darts down the third path, certain that his prey had passed only through there. He makes what one calls in medicine a "diagnosis by exclusion," proceeding under the assumption that the only way to validly determine the condition is to review all the possible cases; of course, if one forgets to review a single possibility, one might make a mistake, and this is what our young calculator did. However, it appears that he hardly ever makes such mistakes, and this is why the extraction of square roots is his favorite game.

Now, what most surprises his audience is the ease with which he extracts cube roots. This operation, when performed by utilizing a mathematical process, is very laborious; but, according to the empirical process that I laid bare and explained to you a couple of minutes ago, it is just as simple and fast as the extraction of a square root. All it amounts to is to try out some numbers and elevate them to the cube, and the boy carries out with the greatest facility these multiplications which it turns out entail relatively small numbers, for if the given number is less than a billion, the cube cannot be larger than three digits, and is only two digits if the number is less than a million.

In brief, the extraordinary faculty of our subject is based entirely on the employment of a special and certainly empirical process of multiplication that I do not understand, one which the boy himself is probably incapable of explaining, but which is rendered possible for him to advantageously use by his prodigious memory of numbers. A number, however large it may be, remains for a very long time engraved in his mind. You have seen, messieurs, with what precision he remembered a number larger than 4 billion that he had calculated in my presence twelve days ago. It is likely that he will not forget it for a long while, and I believe it is mainly by combining partial calculations that he has made previously that he is able to successfully perform multiplications of large numbers.